Pneumatic conveyance of material

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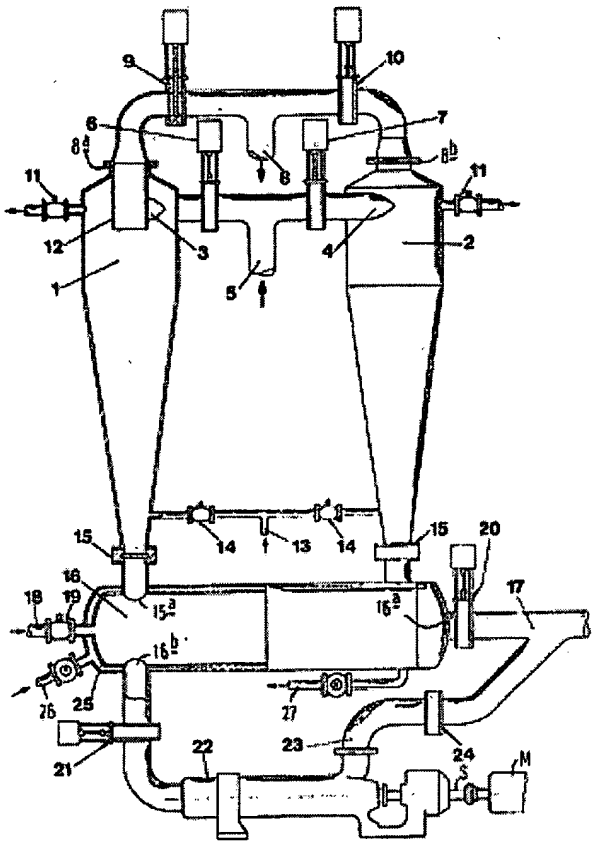
Abstract of **GB2096965**

A method and apparatus for causing flowable material to be conveyed from a first location to a second location comprises evacuating a receptor vessel (1, 2), which vessel (1, 2) has an inlet (3, 4) connected to said first location, whereby flowable material is drawn from the first location into the receptor vessel (1, 2), and an outlet (15a) permitting the flowable material to pass from the receptor vessel (1, 2), under gravity, into a discharge vessel (16). The material is discharged from the discharge vessel (16) through an outlet duct (17) connected to the second location.



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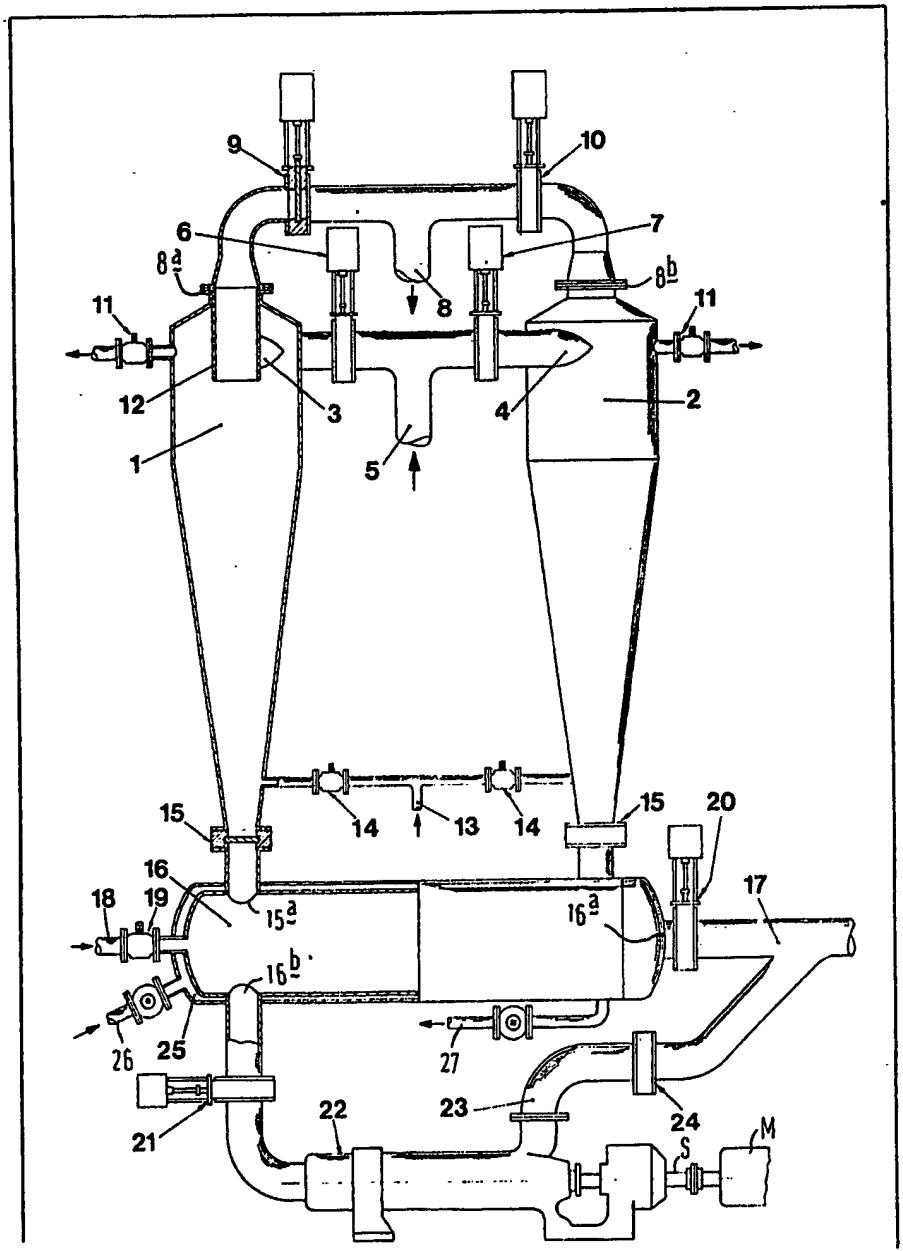
(54) Pneumatic conveyance of material

(57) A method and apparatus for causing flowable material to be conveyed from a first location to a second location comprises evacuating a receptor vessel (1, 2), which vessel (1, 2) has an inlet (3, 4) connected to said first location, whereby flowable material is drawn from the first location into the receptor vessel (1, 2), and an outlet (15*a*) permitting the flowable material to pass from the receptor vessel (1, 2), under gavity, into a discharge vessel (16). The material is discharged from the discharge vessel (16) through an outlet duct (17) connected to the second location.



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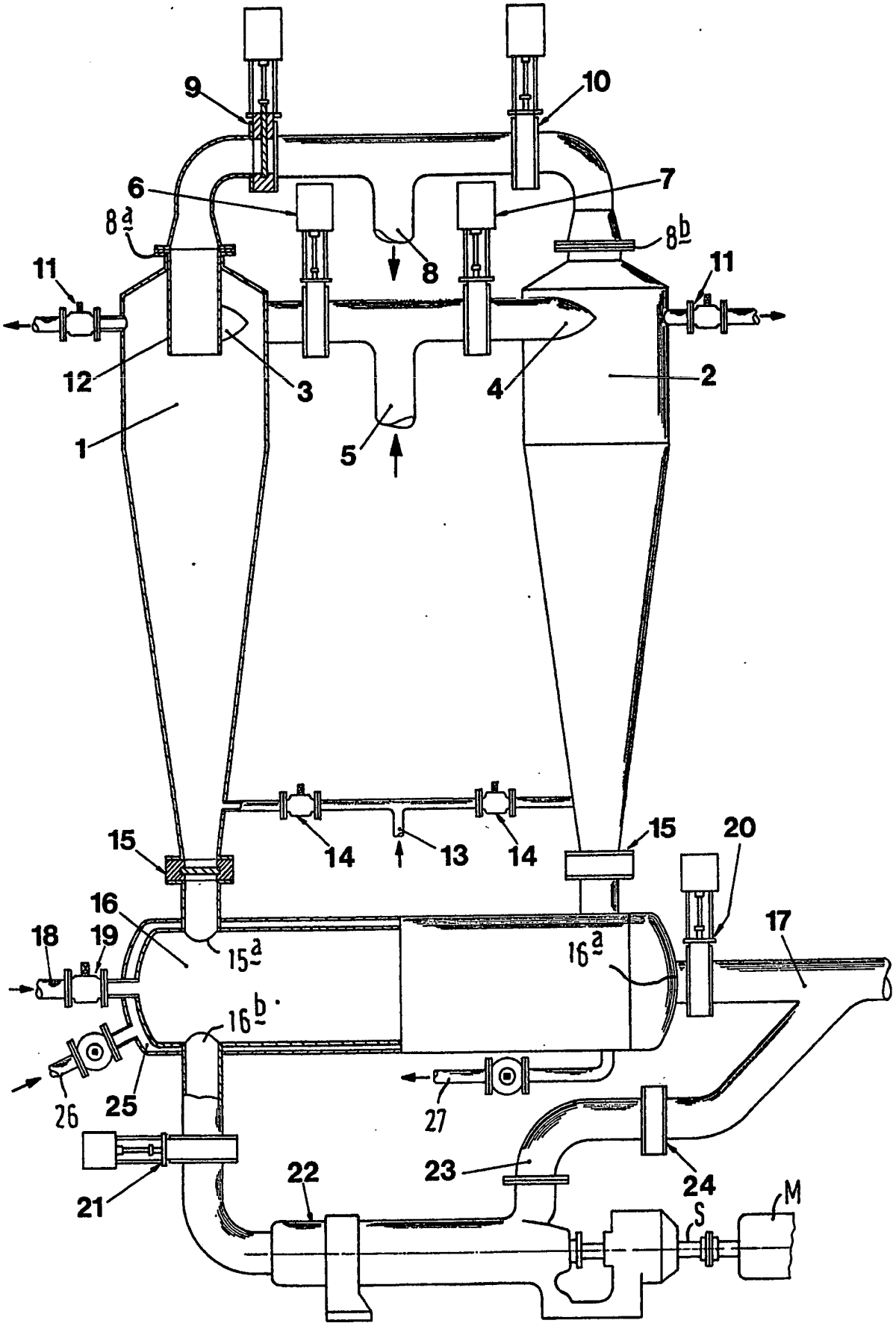

SPECIFICATION

Method and apparatus for causing flowable material to be conveyed.

DESCRIPTION OF THE INVENTION

This invention relates to a method and apparatus for causing flowable material to be conveyed from one location, hereinafter referred to as the first location, to another location, hereinafter referred to as the second location.

By flowable material, we mean powder or particles, a liquid or a solid suspended in a liquid.

It is known to move from a first location to a second location solids which are in the form of powder or grit mixed with a liquid medium such as a sludge or suspension utilising a pneumatic apparatus in a communicating duct which extends between the first and second locations. For example, solids such as waste products are conveyed from one environment to another where they can be more easily stored, transported or used, for eventual disposal or processing.

Such known methods and apparatus which have previously been proposed have disadvantages. The requirements for a suitable apparatus are that the apparatus should be simple and robust and should enable the material to be conveyed from the first location, access to which is often difficult, and discharged to the second location. Such apparatus needs to be able to be used with a wide variety of flowable materials and to cause large quantities thereof to be conveyed quickly.

Conveniently, it is desired that such apparatus should be capable of continuously removing the material from the first location so that there is no build up of material at the first location.

In one such apparatus previously proposed, suction is used to draw the material continuously into one or other of two vessels such as cyclone separators, which may each be pressurised. The apparatus is operated so that when one of the vessels are filled, the material is diverted to the second vessel and whilst this is filling, the first vessel is isolated from the suction and is pressurised. An outlet is then opened whereby an air stream escapes from the vessel under pressure and in so doing removes material therefrom along an outlet duct.

This arrangement of having two vessels alternately filling by suction and emptying by air pressure, has proved a satisfactory apparatus but the provision of both pressure and suction to a single vessel has proved costly in that the vessel has to be constructed to withstand external pressures as a vacuum is formed in the vessel, and internal pressures as the vessel is pressurised. Moreover, valves associated with the apparatus which enable the vessels to be isolated from suction or pressure, have to be capable of dealing with both positive and negative pressures.

Accordingly it is an object of the present invention to provide a new or improved method

According to one aspect of the invention, we provide a method of causing flowable material to be conveyed from a first location to a second location comprising evacuating a receptor vessel, which vessel has an inlet connected to said first location, and an outlet, whereby flowable material is drawn from the first location into the receptor vessel, permitting the flowable material to pass from the receptor vessel, under gravity, through the outlet into a discharge vessel, and discharging the material from the discharge vessel through an outlet duct connected to the second location.

According to a second aspect of the invention, we provide an apparatus for causing flowable material to be conveyed from a first location to a second location comprising a receptor vessel having an inlet and an outlet, the inlet being connectable with the first location, means to evacuate said receptor vessel to cause flowable material to be drawn into the vessel through the inlet, a discharge vessel having at least one inlet connected with the outlet of the receptor vessel, whereby flowable material may pass under gravity from the receptor vessel into the discharge vessel, an outlet duct extending from the discharge vessel and being connected to the second location, discharge means to cause said flowable material to be discharged from the discharge vessel through the outlet duct.

Preferably, two receptor vessels are provided, the outlet of each being connected with an inlet of the discharge vessel, wherein one receptor vessel may be evacuated and hence filled, whilst the other vessel is emptied.

The or each receptor vessel may be isolated from the discharge vessel by means of a valve or valves, and further valves may be provided where a pair of receptor vessels are used so that a vacuum is applied to either the first or the second receptor vessel whilst the other vessel may be emptied.

The means for discharging the flowable material from the discharge vessel may comprise pressurised air which passes into the discharge vessel from an air inlet, and additionally or alternatively the discharge vessel may have a pump means to discharge said flowable material therefrom. Said pump means for discharging said flowable material from the discharge vessel may comprise an impeller means.

The receptor vessel may comprise a cyclone separator or other separation vessel, to separate any solids in the flowable material from any liquids contained therein, although where invention is only to be used with flowable material comprising powder or particles, or liquid, any other type of vessel may be provided.

The inlet to the or each receptor vessel may be arranged to feed said flowable material into the vessel tangentially thus enabling any air contained in said flowable material to be separated from the remainder of the flowable material which may

the or each receptor vessel does not become clogged with flowable material or agglomeration does not occur.

Siad agitating means to prevent clogging or agglomeration may comprise means to pass air into the flowable material adjacent the outlet, but mechanical agitating means or any other desired agitating means may alternatively be provided.

Means may be provided to discharge liquid contained in the flowable material from the or each receptor vessel. For example, a liquid discharge outlet may be provided at a higher point in the vessel than said flowable material outlet.

Where the flowable material comprises a waxy substance, that is a substance whose density increases and hence flowability decreases as the temperature thereof decreases, means may be provided to maintain the temperature of the flowable material above a predetermined temperature. For example, the discharge vessel may be provided with a heating jacket through which hot water, steam or the like is passed.

Said evacuating means may comprise a liquid ring or other vacuum pump, and, compressor means may be used to provide pressurised air into the discharge vessel.

Waste heat from said vacuum pump and/or compressor means may be passed to a heat exchanger which is used to heat said water for the water jacket thereby greatly increasing the efficiency of the apparatus.

If desired, the apparatus may be mounted on a trailer or chassis to enable the apparatus to be transported from site to site. Alternatively, the apparatus may comprise a permanent installation.

The invention will now be described with reference to the accompanying drawing which is a diagrammatic front elevational view, partly in section, of an apparatus in accordance with the invention.

Referring to the drawing, an apparatus for causing flowable material, examples being cement, pulverised fly ash, coal, coke, mill scale, sand aggregate, catalysts, blasting shot and grit, abrasives, grain, lime, digested sewage, detritus, slag, sludges and slurries, water oil sludge, wax or any other granular material, liquid or mixture of granular and liquid materials, to be conveyed from a first location to a second location.

The first location may comprise a silo, tank, digestor, ship's hold, barge, hopper, precipitator, flue, screen, settling bed, sewer, elevator, clarifyer, filter bed, mill bed, elevated area, furnace or other portable or fixed installation.

The apparatus comprises two cyclone separators indicated at 1 and 2, which function as receptor vessels for flowable material and each have an inlet 3, 4 connected to a common feed line 5 which extends to the first location from which the material is to be conveyed. The inlet line 5 may conveniently comprise a flexible hose which is manoeuvred into position so that its inlet extends into the flowable material at said first may alternatively be provided, although a flexible hose is preferable when the apparatus is portable.

It will be appreciated that the apparatus may be supplied with a feed line 5, or the feed line 5 may be connected to the apparatus by the user.

The inlets 3, 4 each feed the material tangentially into the cyclone separators 1, 2, the inlets, 3,4 to the cyclone separators 1,2 being closable by valves 6 and 7 respectively.

A suction line 8 is connected to a vacuum pump (not shown) such as a liquid ring pump or diffusion pump, although any other suitable type of vacuum pump or other means for providing a vacuum may be used. The suction line 8 is divided into two lines which each lead via valve 9 or 10 to a further inlet 8*a*, 8*b* of each of the cyclone separators 1, 2. The inlets 8*a*, 8*b* are at the top of the cyclone separators 1, 2 and internal baffles 12 connected to the inlets 8*a*, 8*b* extend downwardly into the cyclone separators 1, 2 to minimise removal of the flowable material as it enters the separators 1, 2 via the inlets 2, 3 through the suction line 8.

The valves 9, 10 are arranged so that the suction is applied either to the cyclone separator 1 when the inlet valve 6 for the flowable material is open and the valve 7 closed, or the cyclone separator 2 when the inlet valve 7 for the flowable material is open and the valve 6 is closed. When the valves 9 and 6 are open the material is fed into the cyclone separator 1 via the feed line 5 from the tangential inlet 3 until the cyclone separator 1 is full. The valves 9 and 6 are then closed and valves 10 and 7 opened to switch the suction the cyclone separator 2. The flowable material is then fed to the cyclone separator 2 rather than the separator 1.

Instead of providing two separate pairs of valves 9, 10 and 6, 7, if desired, one or both pairs of valves may each be replaced by a diverter valve which serves the same function.

When the flowable material thus enters the cyclone separator 1 or 2 tangentially it gradually settles at the bottom thereof. Where the flowable material comprises solid particles suspended in a liquid, the solids may separate from the liquid sufficiently for at least some of the liquid to be removed from the cyclone separators 1,2 separately and to permit this, each cyclone separator 1, 2 is provided with a tap comprising an outlet valve 11 adjacent the top thereof.

If desired, each cyclone separator 1, 2 may be provided with a relief valve (not shown) through which air may be admitted at atmospheric pressure for example, to assist the discharge of solids from each cyclone separator 1, 2 after filling, which valves may also act as safety valves to open automatically if the pressure in the associated cyclone separator 1, 2 is above a first predetermined pressure and/or below a second predetermined pressure.

The cyclone separators 1,2 each have an outlet valve 15 at the bottom thereof through which the

vessel 16. To prevent close packing of the material at the bottom of each cyclone separator 1, 2 agglomeration or clogging, which could prevent the material from flowing freely, an air line 13 is provided which flows via valves 14 to a position in each cyclone separator 1, 2 at the bottom thereof adjacent outlet 15*a*. A stream of air can thus be injected into the material as it flows out of the cyclone separators 1, 2 so as to maintain the material, at least in the bottom thereof, in an agitated state. It will be noted that the air stream is very small and accordingly there is no significant increase in pressure in the cyclone separators 1, 2 above atmospheric pressure. Alternatively, any other agitating means may be provided in the cyclone separators to prevent agglomeration or packing of the material at the outlets, such as a mechanical agitator.

Although discharge through outlet 15*a* mainly occurs by gravity, it is assisted where an air stream is supplied by the air line 13 by the air entering the separator.

The apparatus is operated so that discharge of one cyclone separator, for example cyclone separator 1, occurs whilst the other cyclone separator 2 is being filled with material. When the cyclone separator 2 is full and the cyclone separator 1 is empty, the operations of the two cyclone separators are reversed so that cyclone separator 1 is filled whilst cyclone separator 2 is emptied.

Although the apparatus has been described with only two cyclone separators 1, 2 if desired more than two may be provided each having appropriate means for filling and emptying as described above in a sequential series of operations as for the two cyclone separator apparatus described above.

Although the receptor vessels have been described as cyclone separators, which are particularly useful for separating solids from liquids in which they are suspended, any other type of receptor vessel may alternatively be provided.

The discharge vessel 16 comprises a plurality of inlets each of which connects with cyclone separator outlet 15*a*. The vessel 16 is provided with two outlets 16*a*, 16*b* for the flowable material, which outlets 16*a*, 16*b* provide two alternative ways of discharging the material from the vessel, but each communicate with a common duct comprising a discharge pipe 17 which extends to a second location and conveys the material from the discharge vessel to the second location. Again, the discharge pipe may comprise a flexible hose or a rigid pipe as desired supplied with the apparatus or connected thereto by a user.

The outlet 16*a* is a blown outlet, that is when the outlet valve at the outlet 16*a* is open, material is blown from the vessel 16 by the pressure of air introduced via an air line 18 when an air inlet valve 19 is open. However, not all materials are easily blown, for example sludge and thus a further which pumping chamber 22 an impeller connected to a shaft S driven by a motor M extends, so that when operated, material is drawn from outlet 16*b* and passes into a duct 23 which communicates with the discharge pipe 17 via a further valve 24.

If desired, when valves 21 and 24 are both closed, material can be discharged by blowing, or with the valves 19 and 20 closed, material is discharged through pumped outlet 16*b*.

When material such as fine dust is to be discharged through the outlet 16*b* by pumping, it has been found convenient to assist the transport of the material from the discharge vessel 16 to the pumping chamber 22, by opening valve 19 and hence pressurising the chamber 16.

Thus the apparatus provides a dual discharge facility which provides considerable versatility and enables the precise method of removal of the flowable material from the discharge vessel 16 to be varied according to the nature of material.

If desired, a diverter valve may be provided at the junction of the outlet duct 17 and duc t 23 instead of the two valves 20 and 24 described, although in an apparatus where only one outlet 16*a* or 16*b* is provided, such a diverter valve may be omitted altogether.

To facilitate the conveyance of solids of a waxy nature, that is solids whose density and hence flowability increases as the temperature of the material falls, it is desirable to provide heating means for maintaining the material warm during the discharge operation. In the example shown, this is achieved by providing the discharge vessel 16, and if required at least the lower half of each receptor vessel 1, 2 also, with a hot-water heating jacket 25. Alternatively a heating coil or steam jacket may be provided or any other heating means.

The heating jacket 25 surrounds the discharge vessel 16 and has a hot water inlet 26 and a cool water outlet 27 which each extend to a heat exchanger (not shown). Desirably, heat produced by the vacuum pump and/or compressor and/or motor may be extracted using a suitable means and fed to the heat exchanger to heat water for the jacket 26, thus considerably increasing the efficiency of the apparatus.

Although internal baffles 12 are provided in the cyclone separators 1, 2, inevitably some of the flowable material will be carried from the cyclone separators 1, 2 by the suction line 8. A further cyclone separator (not shown) or other separation vessel may be provided through which the suction line 8 passes so that material may be separated therefrom and recycled to the inlet line 5 or otherwise disposed of.

The apparatus described has considerable versatility and is capable of use with a wide range of flowable materials. If desired, the flowability of the material can often be enhanced by adding an appropriate carrier liquid to the material at the first location. This liquid can then be removed, at least

If desired the entire apparatus described may be mounted on a trailer or chassis to facilitate transport from one site to another, or may be permanently mounted as a fixed installation.

CLAIMS

1. A method of causing flowable material to be conveyed from a first location to a second location comprising evacuating a receptor vessel, which vessel has an inlet connected to said first location, and an outlet, whereby flowable material is drawn from the first location into the receptor vessel, permitting the flowable material to pass from the receptor vessel, under gravity, through the outlet into a discharge vessel, and discharging the material from the discharge vessel through an outlet duct connected to the second location.

2. An apparatus for causing flowable material to be conveyed from a first location to a second location comprising a receptor vessel having an inlet and an outlet, the inlet being connectable with the first location, means to evacuate said receptor vessel to cause flowable material to be drawn into the vessel through the inlet, a discharge vessel having at least one inlet connected with the outlet of the receptor vessel, whereby flowable material may pass under gravity from the receptor vessel into the discharge vessel, an outlet duct extending from the discharge vessel and being connected to the second location, discharge means to cause said flowable material to be discharged from the discharge vessel through the outlet duct.

3. The invention according to Claim 1 or Claim 2 wherein two receptor vessels are provided, the outlet of each being connected with an inlet of the discharge vessel, wherein one receptor vessel may be evacuated and hence filled, whilst the other vessel is emptied.

4. The invention according to any one of Claims 1 to 3 wherein the or each receptor vessel is isolated from the discharge vessel by means of a valve or valves.

5. The invention according to Claim 3 or Claim 4 where dependant on Claim 3 wherein valves are provided to enable a vacuum suction to be applied to either the first or the second receptor vessel whilst the other vessel may be emptied.

6. The invention according to any one of the preceding claims wherein the means for discharging the flowable material from the discharge vessel comprises pressurised air which passes into the discharge vessel from an air inlet.

7. The invention according to any one of the preceding claims wherein the discharge vessel has a pump means to discharge said flowable material therefrom.

8. The invention according to Claim 7 wherein said pump means for discharging said flowable material from the discharge vessel comprises an impeller means.

9. The invention according to any one of the preceding claims wherein the receptor vessel comprises a cyclone separator or other separation vessel, to separate any solids in the flowable material from any liquids contained therein.

10. The invention according to any one of the preceding claims wherein the inlet to the or each receptor vessel is arranged to feed said flowable material into the vessel tangentially thus enabling any air contained in said flowable material to be separated from the remainder of the flowable material.

11. The invention according to any one of the preceding claims wherein agitating means is provided in the or each receptor vessel to ensure that the outlet of the or each receptor vessel does not become clogged with flowable material or agglomeration does not occur.

12. The invention according to Claim 11 wherein said agitating means comprises means to pass air into the flowable material adjacent the outlet.

13. The invention according to any one of the preceding claims wherein means is provided to discharge liquid contained in the flowable material from the or each receptor vessel.

14. The invention according to Claim 13 wherein said means comprises a liquid discharge outlet at a higher point in the vessel than said flowable material outlet.

15. The invention according to any one of the preceding claims wherein means is provided to maintain the temperature of the flowable material above a predetermined temperature.

16. The invention according to Claim 15 wherein the discharge vessel is provided with a heating jacket through which hot water, steam or the like is passed.

17. The invention according to any one of the preceding claims wherein said evacuating means comprises a vacuum pump.

18. The invention according to any one of the preceding claims wherein compressor means are used to provide pressurised air into the discharge vessel.

19. The invention according to Claim 17 or Claim 18 when dependant on Claim 16, wherein waste heat from said vacuum pump and/or compressor means is passed to a heat exchanger which is used to heat said water for the water jacket.

20. The invention according to any one of claims 2 to 19 when dependant on Claim 2 wherein the apparatus is mounted on a trailer or chassis to enable the apparatus to be transported from site to site.

21. The invention according to any one of the preceding claims wherein the suction input to the receptor vessel and/or the discharge from the discharge vessel is continuous.

22. A method substantially as herein described with reference to the accompanying drawings.

23. An apparatus substantially as herein described with reference to and as shown in the

accompanying drawings.

24. Any novel feature or novel combination of features disclosed herein and/or shown in the accompanying drawings.

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